APPENDIX E

Dr. H.R. Malcom's Preliminary Basin Design

PRELIMINARY DESIGN

Reservoir design is an indeterminate problem. In order to analyze a reservoir for performance in a design storm, the system must be routed. In order to route, the system must be known. In design, the system is being sought. It is necessary, therefore, to select a tentative system, and then route it. If the site must be selected from a number of alternatives, multiple routings can be laborious. A technique for tentative sizing of a system is useful in reducing the number of alternatives to be routed.

A very good approximation of orifice-based detention reservoirs can be obtained by a gross linearization of the inflow and outflow hydrographs. Let the inflow hydrograph rise linearly from the origin to the peak, Qp, and time to peak, Tp. Let the falling limb descend linearly from the peak to zero discharge at time of twice Tp. Let the outflow hydrograph rise linearly from the origin to its peak, Qo, at its intersection with the falling limb of the inflow hydrograph. In the triangular system thus contrived, the storage is the area between the triangles above the outflow hydrograph. By the triangular relationships, the storage required to reduce Qp to Qo can be estimated as:

$$S = (Qp - Qo)\,Tp \qquad \text{(III-21)}$$

in which:

S = Estimated storage required

Qp = Peak discharge of the inflow hydrograph

Qo = Peak discharge of the outflow hydrograph

Tp = Time to peak of inflow hydrograph, measured from time of significant rise of the rising limb to the time to peak. $Tp = \frac{Vol}{1.39\,Qp}$ WHERE Vol = VOLUME UNDER HYDROGRAPH 24-HR DURATION

The expression is in consistent units. If discharges are in cfs, then time must be in seconds to yield storage in cubic feet.

Equation III-1 may be thought of as PDQ routing. It roughly estimates the storage needed to reduce Qp to the target outflow, Qo, without knowing the system. The storage device may be configured accordingly, and the stage-storage function developed.

The outlet device may also be tentatively sized. In order to pick a pipe, one needs a discharge and driving head. With these, the FHWA culvert capacity charts or the orifice equation may be used to select the pipe or pipes to serve as the outlet. From the stage-storage function, determine the stage necessary to provide the estimated storage required. Using that stage and the target peak outflow, select the pipe or pipes. It is emphasized that the technique is approximate, and that the resulting system should be routed to confirm that it will perform satisfactorily.

SUMMARY

The methods of this section have been assembled to support the design of detention systems. Many jurisdictions have preferred methods for hydrograph formulation and flood routing. The final design must be presented using their methods for acceptance. For preliminary site selection, even design refinement, as in spreadsheets, the methods shown here can improve design efficiency. In some cases, they are acceptable for design submission.

The step-function hydrograph formulation is very quickly executed, and it can be shown to match reasonably well longer methods that use the 24-hr center-weighted design storm. Chainsaw routing is an excellent spreadsheet application. The triangular hydrograph approximation can reduce the number of routings required.